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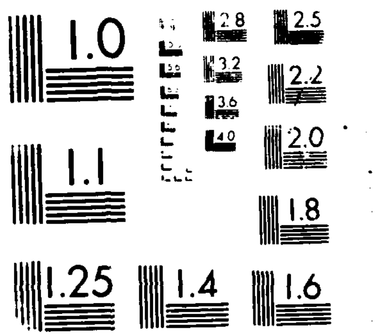
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DEVELOPMENT OF 10TH GRADE NORMS FOR THE ASVAB

D. R. Divgi
Gary E. Horne

A Division of CNA Hudson Institute

CENTER FOR NAVAL ANALYSES

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2. The Armed Services Vocational Aptitude Battery (ASVAB) is administered in high schools as a tool for career guidance and counseling. Currently ASVAB norms based on a nationally representative sample are available for grades 11 and 12 only. This Research Contribution develops nationally representative norms for grade 10.

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DEVELOPMENT OF 10TH GRADE NORMS FOR THE ASVAB

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ABSTRACT

The Armed Services Vocational Aptitude Battery (ASVAB) is administered in high schools and postsecondary schools as a part of the Defense Department's Student Testing Program. Until 1986, high school norms based on a national sample were available for grades 11 and 12 only. These were computed from data collected in 1980 as a part of the Profile of American Youth (PAY) study. Additional data from a nonrandom sample were collected in 1984 by the Military Entrance Processing Command (MEPCOM). The objective of the present study was to develop norms for 10th grade. Tenth grade norms were developed by transforming MEPCOM cumulative percentages into national percentile scores. Transformation curves were obtained by combining information from MEPCOM and PAY samples in grades 11 and 12. The average transformation was then used in 10th grade to convert MEPCOM cumulative percentages into national percentile scores.

EXECUTIVE SUMMARY

The Department of Defense (DOD) uses the Armed Services Vocational Aptitude Battery (ASVAB) to determine the enlistment eligibility of applicants for the four military services. ASVAB scores are also used to assign enlistees to military jobs. In addition, the ASVAB is administered in participating high schools and postsecondary schools as part of the DOD Student Testing Program. It is taken by over a million students per year in over 15,000 schools. ASVAB results, reported as percentile ranks on seven composites, are useful to students and school officials as a counseling resource.

As part of the Profile of American Youth (PAY) study, the ASVAB was administered in 1980 to a nationally representative sample of 16- to 23-year-olds. This sample provided national norms for the youth population (18- to 23-year-olds), two-year colleges, and high school grades 11 and 12.

In high schools, the ASVAB is administered in 10th, 11th, and 12th grades. The form currently used in the Student Testing Program is ASVAB Form 14, which was introduced in July 1984. Until 1986, national high school norms for Form 14 were available for 11th and 12th grades only. Scores of 10th graders had to be interpreted using 11th grade norms. Therefore, in a special administration in late 1984, the Military Entrance Processing Command (MEPCOM) tested all students in grades 9 through 12 in 52 high schools. Since participation by a school was voluntary, this sample was not nationally representative. The objective of the present study was to develop norms for 10th grade by combining information in the PAY and MEPCOM samples.

NORMS

The problem in developing 10th grade norms was to estimate percentile ranks in a truly representative national sample by using data from the nonrandom MEPCOM sample. This could be done by adding information about 11th and 12th grades available in the representative PAY sample. The two data sets were used to obtain, for each composite and sex, the transformation curve that converted cumulative percentages in the MEPCOM sample into percentile scores in the PAY sample. The curve was then used to calculate percentile scores for 10th grade from score distributions in the MEPCOM sample.

Use of the transformation method requires the assumption that the transformation is the same in all grades. This assumption was found to be consistent with available data. Statistical tests showed that observed differences between 11th and 12th grade curves could be attributed to random sampling error.

As an illustration of the results, figure I shows percentile ranks for females on the Academic Ability composite in all three grades. The changes from one grade to the next appear reasonable, not only in this case, but for all composites and both sexes (see figures 10 through 23 in the main text).

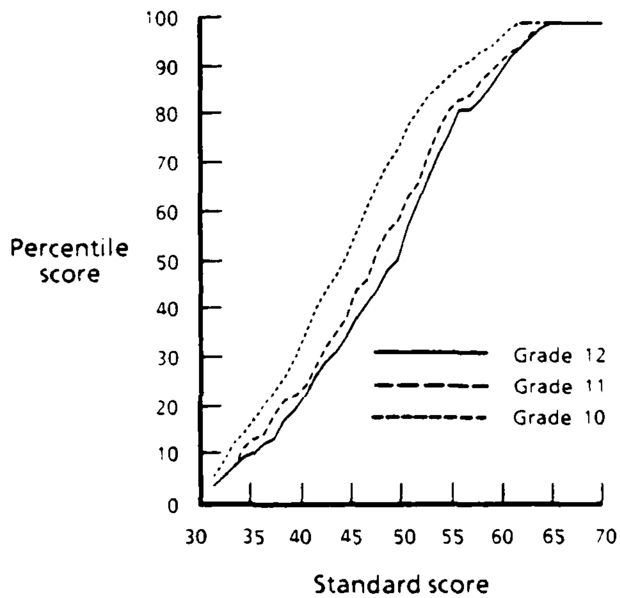

FIG. I: NORMS FOR FEMALES, COMPOSITE AA

An external check on the methodology was made in the following manner. The Verbal composite had earlier been equated to a reading achievement test, providing a conversion of Verbal standard scores into reading grade levels. Therefore, norms for the Verbal composite could be plotted with percentile ranks on the vertical axis as in figure I, and grade levels instead of standard scores on the horizontal axis. This was done for the total grade norms (i.e., with sexes combined). The percentile rank of grade level 10.0 in 10th grade was very close to the ranks of 11.0 in the 11th grade

and 12.0 in the 12th grade. Thus, as figure II shows, 10th grade norms calculated in this study are consistent with 11th and 12th grade norms obtained directly from the PAY sample. This finding provides strong evidence that the transformation method is valid.

The norms developed in this study describe the results that would have been obtained if 10th graders had been tested in the PAY study. They have been used to generate 10th-grade score reports sent to students and counselors. The main text presents norm tables for all composites in the Student Testing Program.

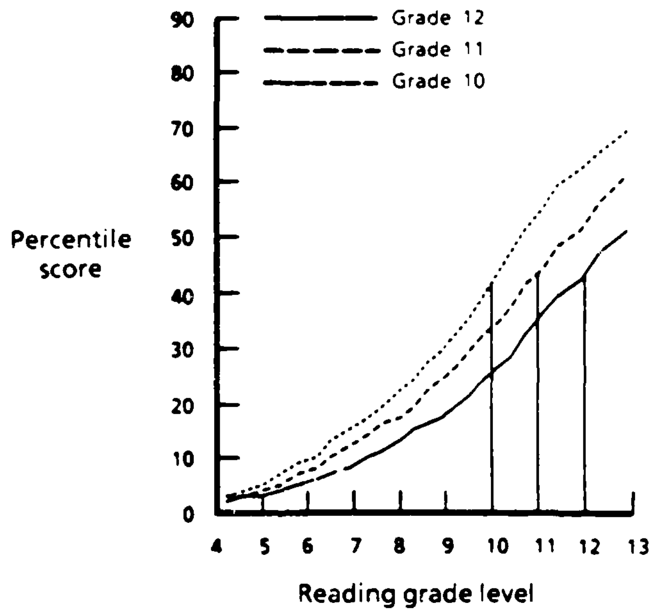

FIG. II: TOTAL GROUP NORMS, VERBAL COMPOSITE: STANDARD SCORE CONVERTED TO C.A.T. GRADE LEVEL

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INTRODUCTION

The Department of Defense (DOD) uses the Armed Services Vocational Aptitude Battery (ASVAB) to determine the enlistment eligibility of applicants for the four military services. ASVAB scores are also used to assign enlistees to military jobs. In addition, the ASVAB is administered in participating high schools and postsecondary schools as part of the DOD Student Testing Program. It is taken by over a million students per year in over 15,000 schools. ASVAB results are useful to students and school officials as a counseling resource. Norms for the ASVAB are based on a nationally representative sample tested in 1980 as part of the Profile of American Youth (PAY) study [1].

CONTENTS OF THE ASVAB

The ASVAB contains 10 subtests: General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto/Shop Information (AS), Math Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI). The Verbal (VE) subtest is defined as the sum of WK and PC. Two subtests, NO and CS, are tests of speed in handling numerical and symbolic material. Because individual items in these subtests are very easy, the examinee's score depends primarily on the number of items answered within the allotted time. All other subtests are power tests with liberal time limits.

Among the power tests, Auto/Shop and Electronics Information require specific information that examinees are likely to have learned on their own, through reading and practical experience, rather than from instruction in school. Mechanical Comprehension also requires this type of information in addition to knowledge of basic physics.

When ASVAB scores are reported to students and counselors, subtests are combined into academic and occupational composites. The three academic composites are Academic Ability (AA), Verbal (VBL, to be distinguished from subtest VE), and Mathematics (MTH). They are useful in predicting a student's educational progress in areas requiring verbal and mathematical skills. The four occupational composites are Mechanical and Crafts (M&C, different from subtest MC), Business and Clerical (BC), Electronics and

Electrical (EE), and Health, Social, and Technology (HST). Scores on these composites indicate a student's aptitude for careers in different areas.

DOD STUDENT TESTING PROGRAM

The DOD Student Testing Program provides the ASVAB, free of charge, to participating high schools and postsecondary schools. It has two major goals. One is to help students identify aptitudes and plan their education and careers. Toward this end, percentile scores on the seven composites are provided to students and their counselors. The other goal is to help DOD attract well-qualified volunteers. Therefore, ASVAB scores of 11th and 12th grade students are made available to military recruiters.

ASVAB forms 14a, 14b, and 14c are used in schools. They are parallel to Form 8a which was used in PAY [2]. Percentile scores reported to counselors are based on norms for the student's grade, for grade and sex, and for the youth population (ages 18 through 23). Scores reported to students use norms for their own grade and sex, and for the youth population. However, from July 1984 to September 1986, 10th graders were scored against 11th grade norms because 10th grade norms were not available.

Norms for 11th grade, 12th grade, and postsecondary schools are based on students in the PAY sample, which includes ages 16 through 23 years. The youth population norms are based on 18- to 23-year olds in this sample. In combination with the *Military Career Guide*, published by the DOD Student Testing Program, percentile ranks based on these norms help students estimate their chances of qualifying for various military occupations.

MEPCOM DATA

Proper interpretation of scores of 10th graders requires norms for this grade. Therefore, in 1984, the Military Entrance Processing Command (MEPCOM) administered the ASVAB to students in grades 9 to 12 in more than 50 schools that agreed to participate. Data for grades 10 to 12 were used in this study.

Because participation by the schools was voluntary, the students tested do not constitute a nationally representative sample. Therefore, score distributions from the MEPCOM sample cannot provide national norms directly. However, they can be adjusted by using other available information, such as

the national PAY sample available for grades 11 and 12. The 11th and 12th grade data in the two samples were combined to find a method of obtaining national norms from the MEPCOM sample. The same method was then used in 10th grade.

DATA AND METHODOLOGY

AVAILABLE DATA SETS

The PAY data were obtained by administering ASVAB Form 8a to a nationally representative sample of 11,878 persons in the age range of 16 to 23 [1]. Some groups, such as Blacks and Hispanics, were oversampled. Weights based on sex, race, and other variables were used to make the weighted sample match the national population.

The ASVAB forms used in the DOD Student Testing Program are 14a, 14b, and 14c. These have been found to be parallel to Form 8a [2]. Therefore 11th and 12th grade students in the PAY data set could be used to develop high school norms [3]. Unweighted sample sizes were 1,304 for grade 11 and 1,253 for grade 12. Weights calculated in the original study [1] were used while computing percentile scores.

The MEPCOM sample used in this study consists of 10th to 12th grade students in 52 high schools that accepted MEPCOM's invitation to participate in the study. In order to avoid the sample's being biased through student self-selection, the battery was administered to every student in school on the day of testing. The MEPCOM sample is nonrepresentative primarily because the high schools were self-selected; i.e., it includes only those schools that agreed to participate.

Appendix A provides detailed information about the data sets.

CALCULATION OF NORMS

The problem was to adjust results from the nonrandom MEPCOM sample so that the score distributions would be equivalent to those from a random national sample. The first step was to correct for the oversampling of minorities in the MEPCOM sample. This was done by assigning weights to individuals according to sex and race/ethnicity. The weights were calculated to ensure that, in each grade, the sex by race/ethnicity proportions in the weighted sample equaled those in the 1980 census (table 260 in [6]). Because of overlap between categories, frequency of "Whites-and-others" was calculated as the total minus frequencies of Blacks and Hispanics.

Results for grades 11 and 12 showed that, while weighting reduced the difference between PAY and MEPCOM mean scores, the correction was far from adequate. Further adjustments were needed to obtain from the MEPCOM sample percentile scores that approximated those from the PAY sample.

TRANSFORMATION OF PERCENTILE SCORES

To develop grade norms from the MEPCOM sample, the relationship between this sample and the national population must be known. This relationship must be found from data in grades 11 and 12, and then used to develop norms in lower grades. Such extrapolation to lower grades requires that the relationship be the same in all grades (except for sampling errors).

With the exception of the BC composite, MEPCOM students tend to score lower than PAY students. Such a difference can be expressed in terms of means or medians, but this is not enough for obtaining norms. Percentile ranks are to be calculated for all standard scores. Therefore, an entire MEPCOM distribution must be related to the corresponding PAY distribution in a manner that does not require assumptions about the distributions (e.g., normality).

A percentile score shows an individual examinee's position relative to the national population. When a group of examinees is to be described, a complete description of its performance relative to the national population is provided by its distribution of percentile scores. Therefore, if the distribution of percentile ranks in the MEPCOM sample is the same in all grades, its relationship to the national population is grade invariant. This relationship can be found from 11th and 12th grade data and used to compute norms for 10th grade. (It does not matter if the relationship varies with sex or composite.)

In this report, the generic term "cumulative percentage" will refer to values obtained from a MEPCOM sample. Cumulative percentages in a national sample will be called "percentile ranks" or "percentile scores" because they are printed in score reports. For grades 11 and 12, these are obtained directly from the PAY sample; for grade 10 they are estimates calculated in this study.

For present purposes, the best way to display a distribution is to plot cumulative percentages. Figure 1 shows such a plot for composite AA, using data from females in grades 11 and 12; the PAY percentile score is on the Y axis and corresponding cumulative percentage in the MEPCOM sample is on the X axis. The two curves are very close together, which indicates that the assumption of grade invariance is correct. These curves can be used to transform MEPCOM cumulative percentages into national percentile scores.

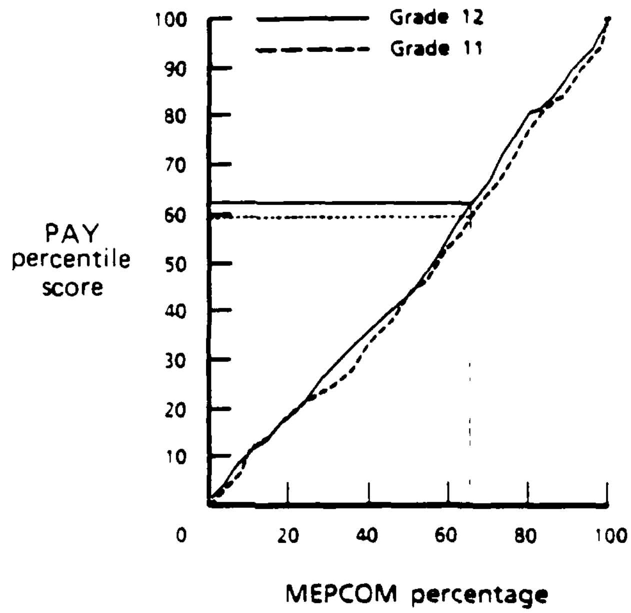

FIG. 1: TRANSFORMATIONS FOR COMPOSITE AA (FEMALE SAMPLE)

Figure 1 contains an illustration of the transformation method. For a standard score of 46, the cumulative MEPCOM percentage in grade 10 was 65.0. In figure 1, this value is represented by the vertical line. It intersects the solid curve (grade 12) at a percentile score of 61.9 and the dashed curve (grade 11) at a percentile score of 59.2. These are the estimates of the 10th grade percentile score corresponding to the standard score of 46, based on transformations obtained from 12th and 11th grades. According to a statistical test described later, the difference between the two values is due to sampling fluctuations. It appears in figure 1 as the vertical distance between the two curves.

The basic transformation method illustrated in figure 1 was refined to reduce sampling errors. For each integer value of the MEPCOM cumulative

percentage, the mean percentile rank in grades 11 and 12 was calculated; i.e., the two curves in figure 1 were averaged. The averaged curve was then smoothed, using a five-point rolling average. (Appendix B gives details of this procedure.) Figure 2 shows the smoothed transformation for Academic Ability in the female sample. It yields the 10th grade percentile rank for the standard score of 46 as 60.8, which becomes 61 after rounding.

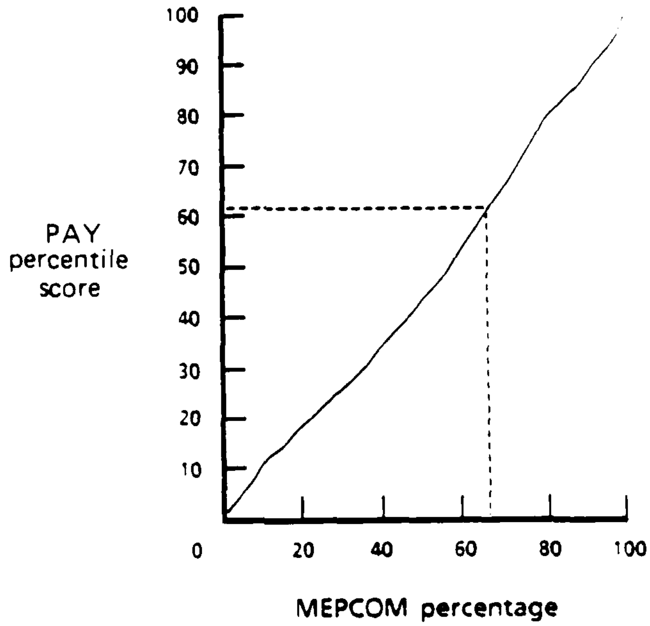

FIG. 2: USE OF AVERAGED SMOOTHED TRANSFORMATION

The transformation method for estimating norms is robust in the sense that it does not involve any assumptions about the way in which PAY and MEPCOM samples differ. For instance, MEPCOM students were tested later in the year than those in the PAY sample. However, as long as any such influence operates in all grades, the assumption of grade-invariant transformation remains valid. Therefore, the norms calculated in this study describe the results that would have been obtained if 10th graders had been tested in the PAY study.

TESTING GRADE INVARIANCE

Because PAY data are available for two grades, it is possible to test the assumption that, for any given composite and sex, the transformation from MEPCOM cumulative percentage to the PAY percentile score is grade invariant. As figure 1 illustrates, the transformations obtained from grades 11 and 12 are bound to differ due to sampling errors. The question is whether observed differences are small enough to be attributed to random error.

Since different composites are correlated, comparisons of their transformation curves are not independent. Therefore, a multivariate chi-square test was developed. This test, which assumes composite scores to be normally distributed, takes correlations into account. Appendix B presents a detailed description of the test. The test showed that differences between 11th and 12th grades were statistically nonsignificant.

Since the data support the assumption of grade invariance, transformations from 11th and 12th grades can be averaged and used to compute percentile scores in lower grades.

RESULTS

DATA EDITING

The researchers dropped 5 of the 52 MEPCOM schools: In 3 schools, data were missing in one or more grade, and in 2 others, the number of students tested was much smaller than normal attendance rate. In addition, the study dropped 246 individual students because they had left all items blank on one or more subtest. Table 1 shows the composition of the edited MEPCOM sample. While the sample size drops as grade increases, it remains more than twice as large as the PAY sample size. As in the PAY sample, Blacks and Hispanics were oversampled. Appendix A gives details of the data checking and editing.

TABLE 1

COMPOSITION OF EDITED MEPCOM SAMPLE

		Percent		
Grade	N	Black	Hispanic	Female
10	3,878	17.3	10.2	50.4
11	3,263	18.6	9.1	50.3
12	2,682	17.2	8.2	51.4

Because of the oversampling of minorities, the study used a weighted sample to calculate score distributions leading to the norms. For each grade and sex, a weight was calculated for each population group (Black, Hispanic, White-and-others) so that the proportion of each group by sex combination in the weighted sample equaled that in the 1980 census. The weights changed slightly with grade. Table 2 presents their values.

NORMS

The test for grade invariance of transformation curves yields chi-square statistics with 14 degrees of freedom. The chi-square values were 17.5 for

males and 19.2 for females; the corresponding tail probabilities were .23 and .16. Thus, observed differences between 11th and 12th grade transformation curves are not statistically significant.

TABLE 2

WEIGHTS FOR SUBGROUPS IN THE MEPCOM SAMPLE

	Male			Female		
Grade	White	Black	Hispanic	White	Black	Hispanic
10	1.07	0.88	0.95	1.07	0.88	0.58
11	1.06	0.81	1.14	1.12	0.77	0.55
12	1.06	0.88	1.07	1.07	0.77	0.66

Figures 3 through 9 show the averaged, smoothed transformation curves. (Figure 2 illustrates their use.) Most of these curves are below the 45-degree line, which means that MEPCOM students tended to score lower than PAY students. One major exception is the Business and Clerical composite, which contains the Coding Speed subtest. Because students were tested in large groups, time limits for speed tests could not be strictly enforced; therefore, scores on these subtests may be somewhat inflated [7].

Tables 3 through 9 present 10th grade norms for the seven composites. Figures 10 through 23 graphically show norms for all three grades. The curves show smooth and gradual changes from one grade to another, indicating that the transformation method has worked satisfactorily. (Norms for grades 11 and 12 are taken from [3].)

Note that the transformation corrects for all sources of differences between MEPCOM and PAY samples. In addition to differences in ability levels, this includes disturbances such as nonstandard administration and variations in the date of testing. The only condition is that the effect of such disturbances be the same on all grades in any given school, hence the same on all grades in the MEPCOM sample as a whole. The chi-square test shows that this condition was satisfied. Hence, although testing dates in the MEPCOM sample were spread over 4 months, the 10th grade norms correspond to testing at the same time of the year as PAY did, i.e., during summer.

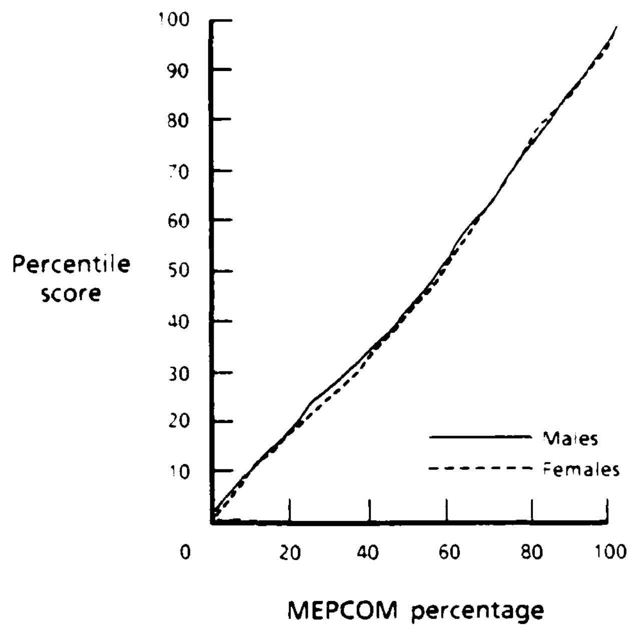

FIG. 3: TRANSFORMATION CURVES FOR COMPOSITE AA

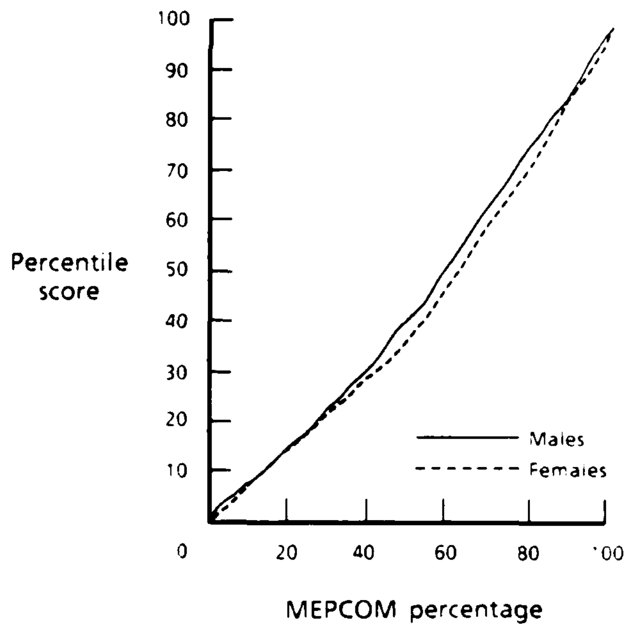

FIG. 4: TRANSFORMATION CURVES FOR COMPOSITE VBL

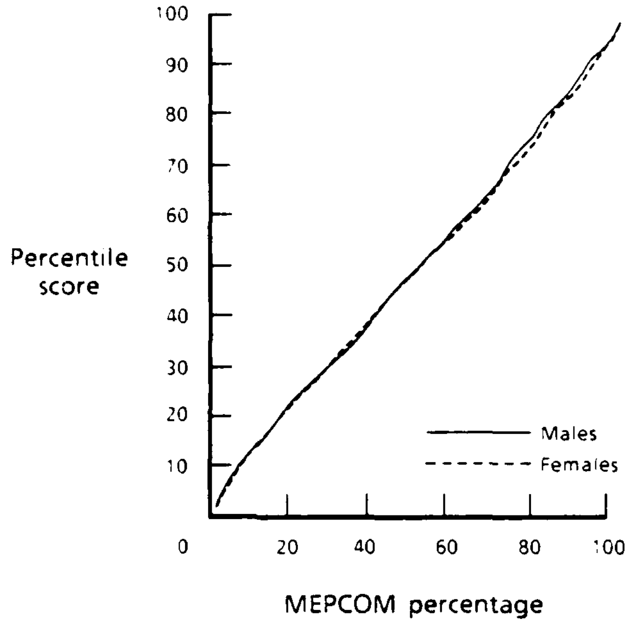

FIG. 5: TRANSFORMATION CURVES FOR COMPOSITE MTH

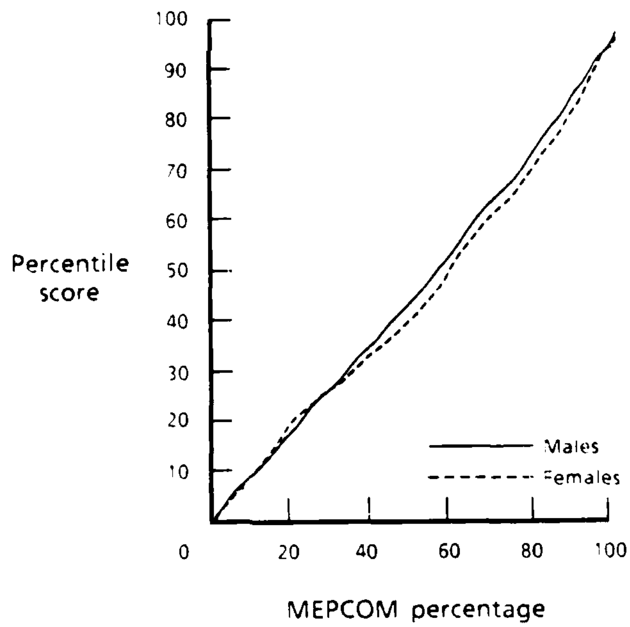

FIG. 6: TRANSFORMATION CURVES FOR COMPOSITE M&C

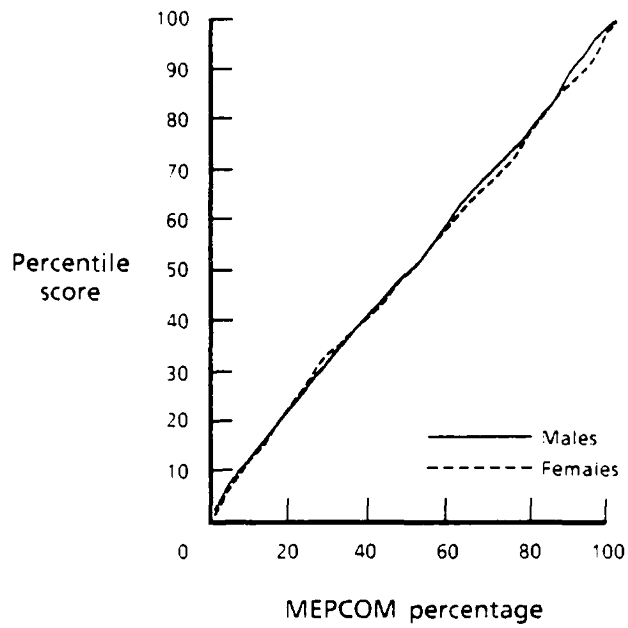

FIG. 7: TRANSFORMATION CURVES FOR COMPOSITE BC

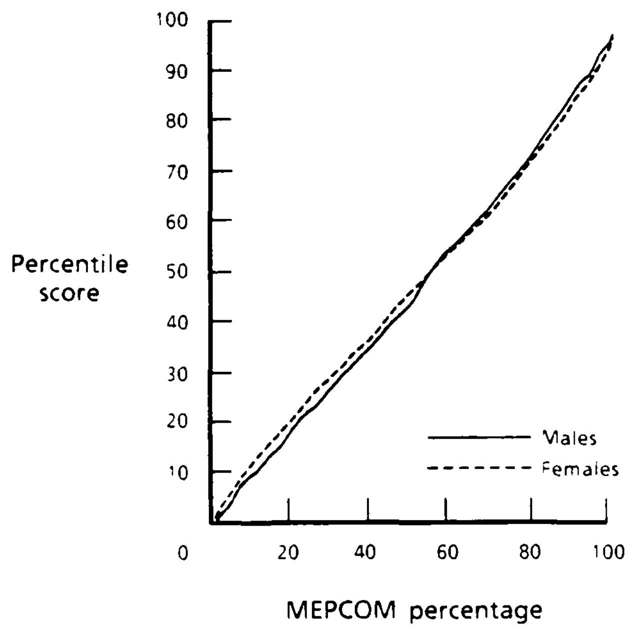

FIG. 8: TRANSFORMATION CURVES FOR COMPOSITE EE

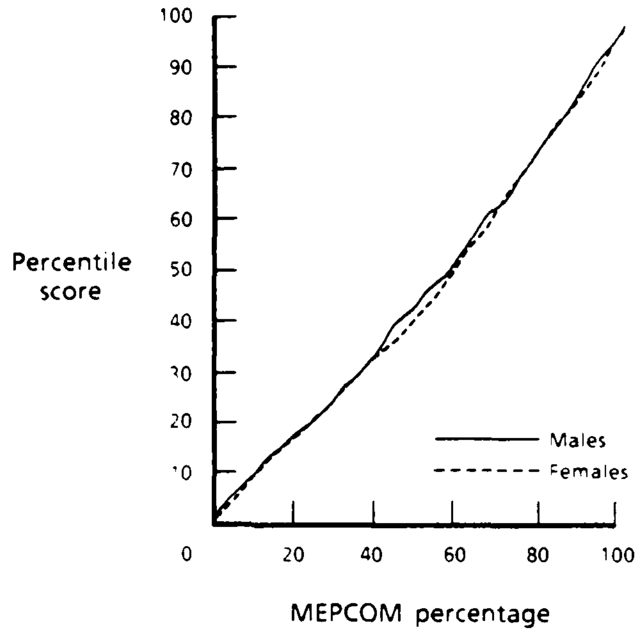

FIG. 9: TRANSFORMATION CURVES FOR COMPOSITE HST

EXTERNAL CHECK

The chi-square test provided an internal check on the transformation method. An external check was also made. The ASVAB Verbal composite has been equated to the California Achievement Test (C.A.T.) Reading Total. The equating table converts each Verbal standard score into a reading grade level. Therefore, the Verbal norms can be displayed by plotting percentile scores against grade levels. Figure 24 shows total group norms in this manner. (The equating table was smoothed by fitting grade level as a fifth-degree polynomial of the ASVAB score.)

If 10th grade norms derived in this study are correct, they should show consistency with 11th and 12th grade norms obtained directly from the PAY sample. Therefore, figure 24 has vertical lines at grade levels of 10.0, 11.0, and 12.0 up to the point where they meet the curves for the corresponding grades. Ideally, the intersections should occur at the same percentile score for all grades. (This percentile score should be 50 because, by definition, the grade level 10.0 is the median of grade 10, etc.)

TABLE 3

PERCENTILE RANKS FOR COMPOSITE AA

Score	Males	Females	Total
≤25	1	1	1
26	2	1	2
27	3	1	2
28	4	2	3
29	4	2	3
30	6	3	5
31	8	5	7
32	10	8	9
33	13	12	12
34	16	14	15
35	18	17	18
36	22	20	21
37	25	23	24
38	27	26	27
39	30	30	30
40	34	35	35
41	37	40	38
42	40	44	42
43	43	47	45
44	46	51	48
45	50	56	53
46	54	61	58
47	59	66	62
48	62	70	66
49	64	73	69
50	68	78	73
51	72	81	76
52	75	84	79
53	78	86	82
54	82	88	85
55	85	90	87
56	87	91	89
57	89	93	91
58	92	94	93
59	95	96	95
60	97	98	97
61	98	99	99
≥62	99	99	99

TABLE 4

PERCENTILE RANKS FOR COMPOSITE VBL

Score	Males	Females	Total
≤23	1	1	1
24	2	1	2
25	4	1	3
26	4	2	3
27	5	3	4
28	6	4	5
29	8	7	7
30	9	9	9
31	11	10	10
32	13	12	13
33	16	14	15
34	18	17	17
35	19	19	19
36	22	21	22
37	25	24	24
38	27	26	27
39	30	29	29
40	32	31	32
41	35	35	35
42	39	40	39
43	42	44	43
44	44	49	47
45	48	53	51
46	52	58	55
47	56	62	59
48	59	65	62
49	63	68	65
50	67	72	69
51	71	76	73
52	75	80	77
53	78	84	81
54	82	87	85
55	84	90	87
56	87	92	89
57	90	94	92
58	94	97	95
59	96	98	97
60	98	99	98
≥61	99	99	99

TABLE 5

PERCENTILE RANKS FOR COMPOSITE MTH

Score	Males	Females	Total
≤31	1	1	1
32	2	1	1
33	3	1	2
34	6	3	5
35	9	5	7
36	13	10	11
37	16	13	15
38	20	16	18
39	24	20	22
40	28	26	27
41	32	33	33
42	38	40	39
43	43	45	44
44	48	50	49
45	52	54	53
46	55	58	57
47	59	62	60
48	61	67	64
49	64	70	67
50	66	72	69
51	69	74	72
52	73	78	76
53	76	81	79
54	80	83	82
55	82	85	84
56	84	88	86
57	86	90	88
58	89	92	90
59	91	93	92
60	92	94	93
61	93	95	94
62	94	96	95
63	95	97	96
64	97	98	98
65	98	99	99
≥66	99	99	99

TABLE 6

PERCENTILE RANKS FOR COMPOSITE M&C

Score	Males	Females	Total
≤30	1	1	1
31	2	2	2
32	4	5	5
33	7	9	8
34	9	15	12
35	11	21	16
36	15	26	20
37	18	31	24
38	21	36	29
39	25	41	33
40	28	47	37
41	32	55	43
42	35	60	47
43	38	64	51
44	42	68	55
45	45	73	59
46	49	78	63
47	53	82	67
48	58	85	71
49	62	89	75
50	65	91	78
51	68	94	81
52	72	95	83
53	76	96	85
54	79	97	88
55	82	98	90
56	86	99	92
57	88	99	93
58	90	99	95
59	93	99	96
60	94	99	96
61	95	99	97
62	97	99	98
63	98	99	98
≥64	99	99	99

TABLE 7

PERCENTILE RANKS FOR COMPOSITE BC

Score	Males	Females	Total
≤25	1	1	1
26	2	1	2
27	3	1	2
28	4	1	3
29	6	2	4
30	8	3	5
31	10	4	7
32	11	5	8
33	14	7	10
34	16	8	12
35	19	10	14
36	21	12	17
37	24	14	19
38	27	17	22
39	31	21	26
40	35	25	30
41	38	28	33
42	42	33	38
43	45	36	41
44	49	40	45
45	53	44	48
46	57	49	53
47	62	55	59
48	67	60	64
49	70	64	67
50	73	68	71
51	77	71	74
52	80	75	78
53	83	80	82
54	88	84	86
55	91	87	89
56	93	89	91
57	95	91	93
58	97	94	95
59	98	96	97
60	99	98	98
≥61	99	99	99

TABLE 8

PERCENTILE RANKS FOR COMPOSITE EE

Score	Males	Females	Total
≤ 30	1	1	1
31	2	3	3
32	4	5	4
33	7	7	7
34	10	11	10
35	13	15	14
36	16	19	18
37	21	25	23
38	23	29	26
39	27	34	31
40	30	39	34
41	34	44	39
42	37	48	43
43	41	53	47
44	43	57	50
45	47	60	54
46	53	64	59
47	56	68	62
48	60	72	66
49	63	76	69
50	67	80	73
51	70	83	76
52	73	86	79
53	77	87	82
54	80	89	84
55	82	91	87
56	85	92	89
57	87	93	90
58	89	95	92
59	90	96	93
60	93	98	96
61	95	99	97
62	96	99	97
63	97	99	98
64	98	99	99
≥ 65	99	99	99

TABLE 9

PERCENTILE RANKS FOR COMPOSITE HST

Score	Males	Females	Total
≤26	1	1	1
27	2	1	1
28	2	1	2
29	4	2	3
30	5	3	4
31	7	5	6
32	9	8	9
33	12	11	12
34	14	14	14
35	17	17	17
36	19	21	20
37	22	25	23
38	25	30	27
39	28	34	31
40	31	37	34
41	35	42	38
42	39	46	43
43	41	51	46
44	44	56	50
45	47	61	54
46	50	67	58
47	54	70	62
48	57	74	66
49	62	79	70
50	64	81	72
51	68	84	76
52	72	86	79
53	75	89	82
54	78	91	84
55	81	93	87
56	85	95	90
57	89	96	92
58	91	97	94
59	93	98	95
60	94	98	96
61	96	99	98
62	98	99	98
≥63	99	99	99

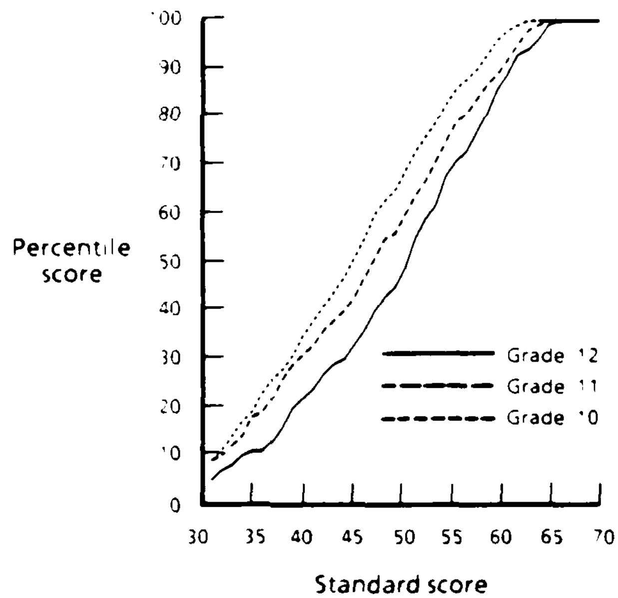

FIG. 10: **NORMS FOR MALES, COMPOSITE AA**

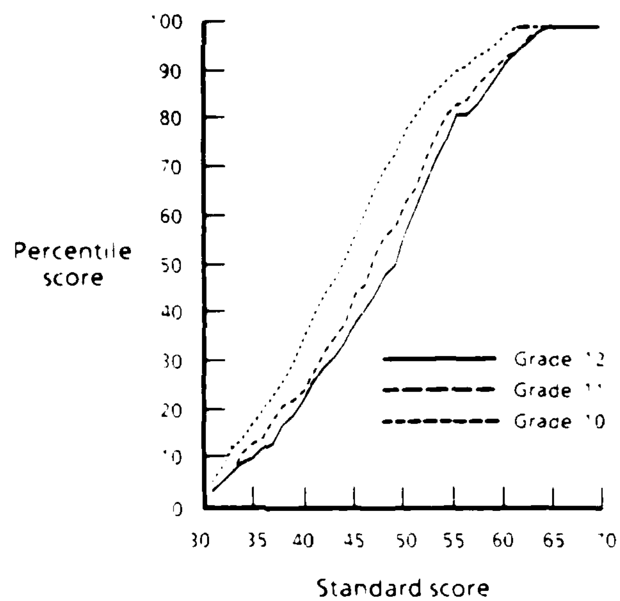

FIG. 11 **NORMS FOR FEMALES, COMPOSITE AA**

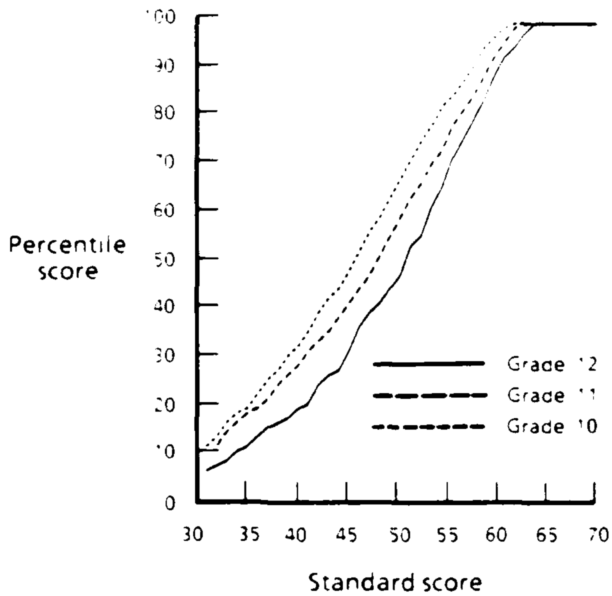

FIG. 12: **NORMS FOR MALES, COMPOSITE VBL**

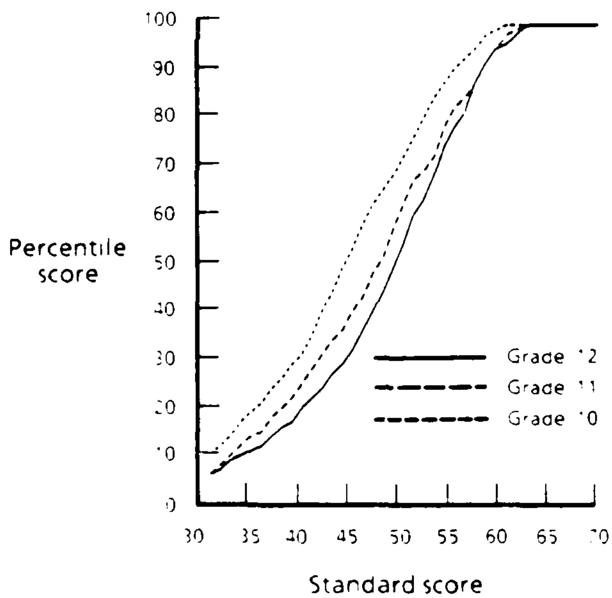

FIG. 13: **NORMS FOR FEMALES, COMPOSITE VBL**

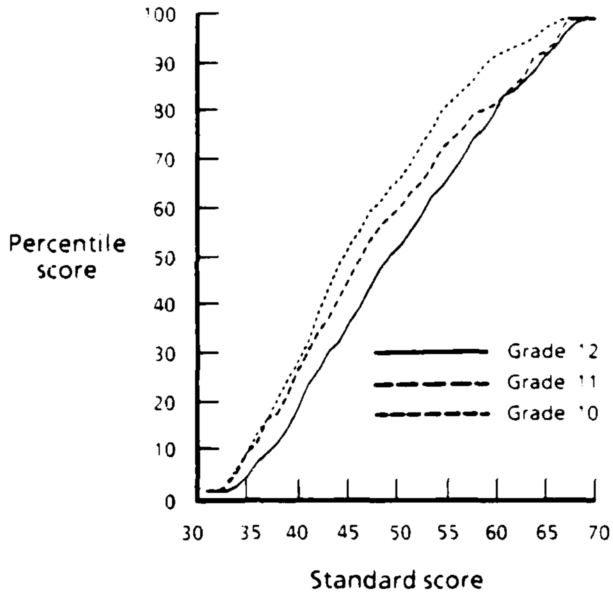

FIG. 14: **NORMS FOR MALES, COMPOSITE MTH**

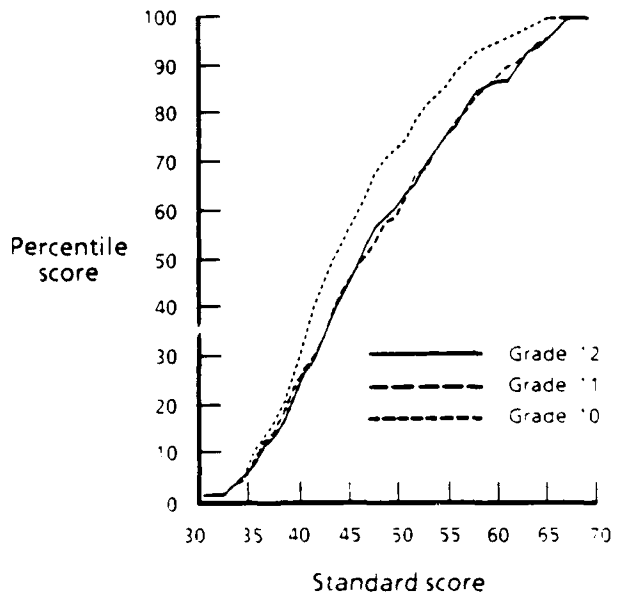

FIG. 15: **NORMS FOR FEMALES, COMPOSITE MTH**

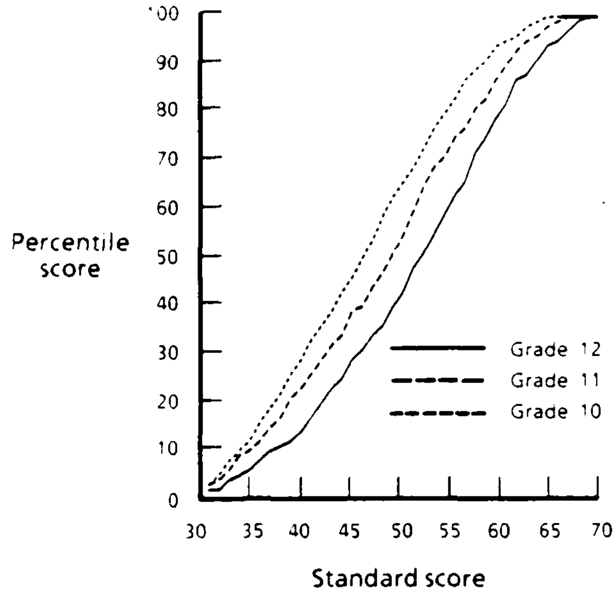

FIG. 16: **NORMS FOR MALES, COMPOSITE M&C**

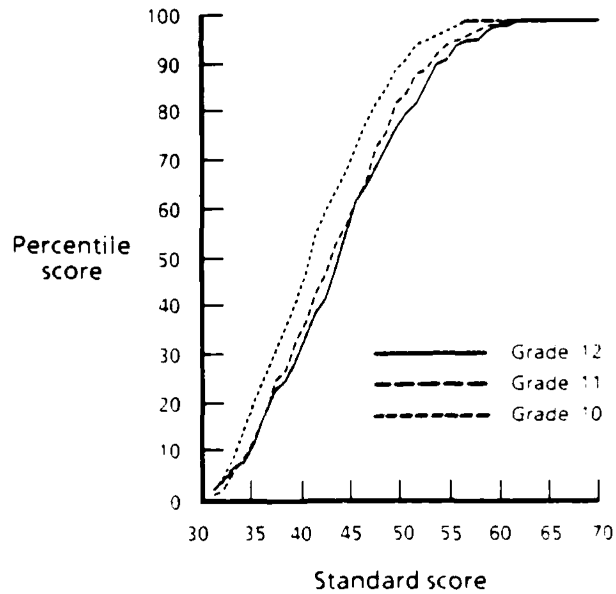

FIG. 17: **NORMS FOR FEMALES, COMPOSITE M&C**

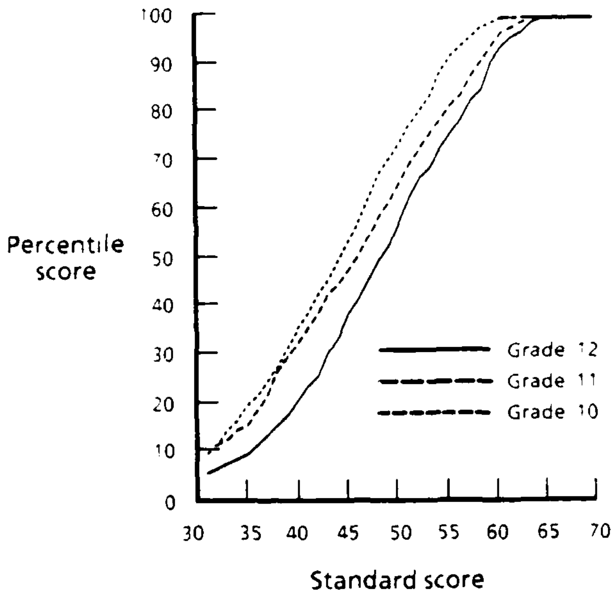

FIG. 18: NORMS FOR MALES, COMPOSITE BC

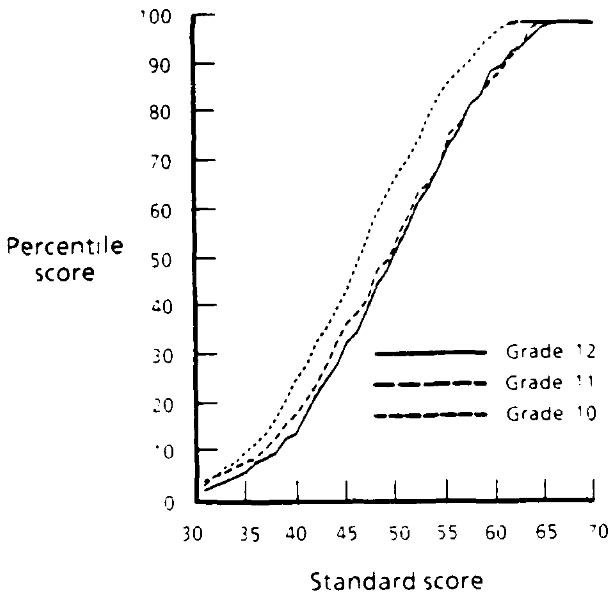

FIG. 19: NORMS FOR FEMALES, COMPOSITE BC

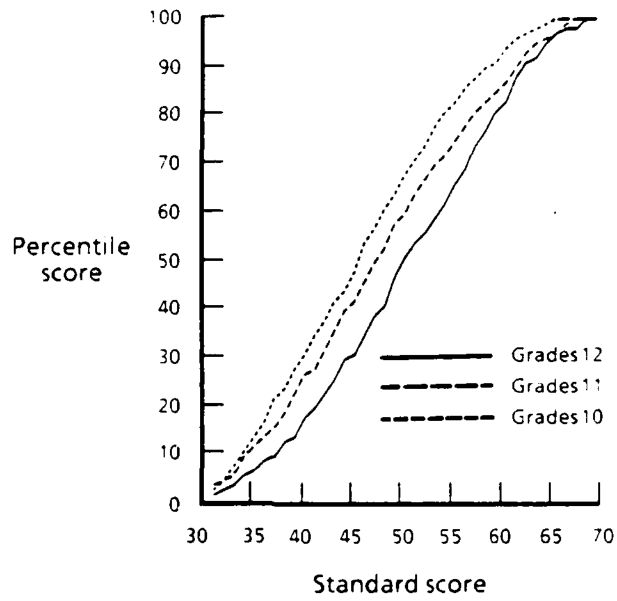

FIG. 20: **NORMS FOR MALES, COMPOSITE EE**

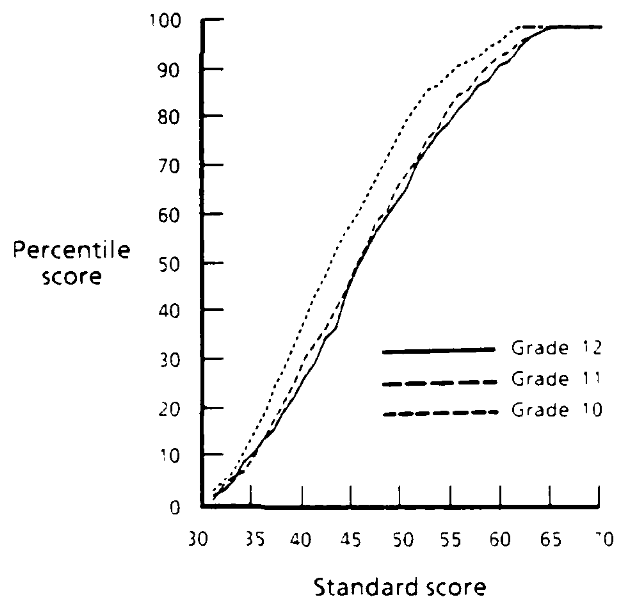

FIG. 21: **NORMS FOR FEMALES, COMPOSITE EE**

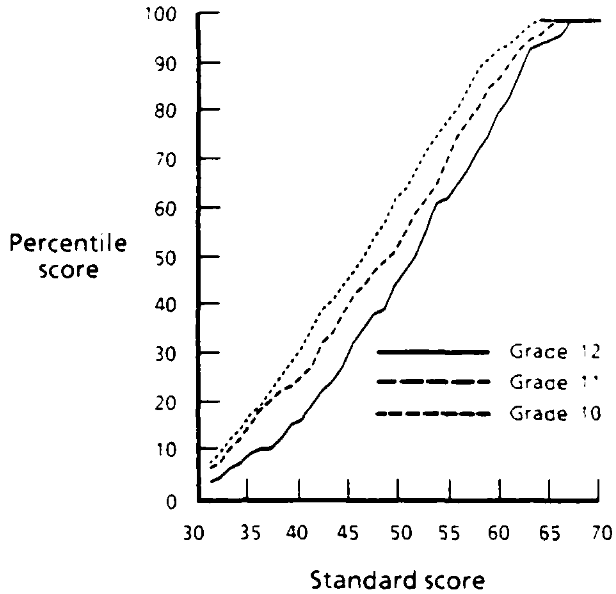

FIG. 22: NORMS FOR MALES, COMPOSITE HST

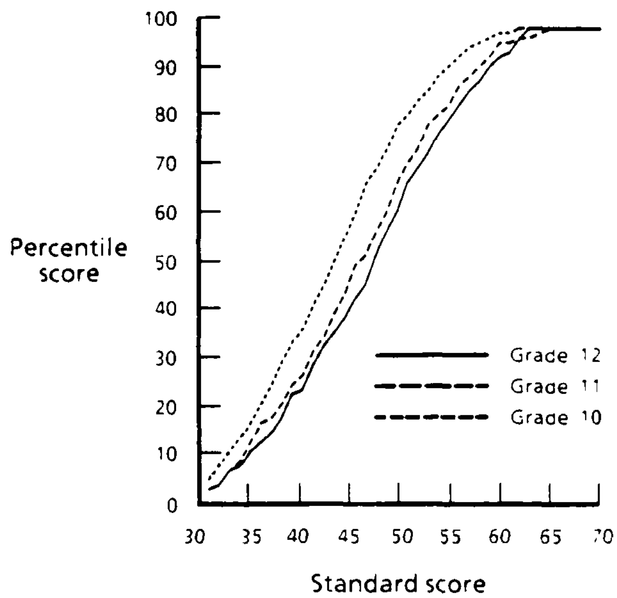

FIG. 23: NORMS FOR FEMALES, COMPOSITE HST

Figure 24 shows that the vertical lines intersect the norm curves at almost but not exactly the same values: 42 for grade 10, 44 for grade 11, and 43 for grade 12. The differences are well within sampling errors. (Note that norms for grade 10 are derived from five distinct samples, with effective PAY sample sizes being below 900 per grade.[1] Additional random error enters through the equating of ASVAB to C.A.T.) The departure from the ideal value of 50 implies that the norming samples for C.A.T. were not nationally representative.

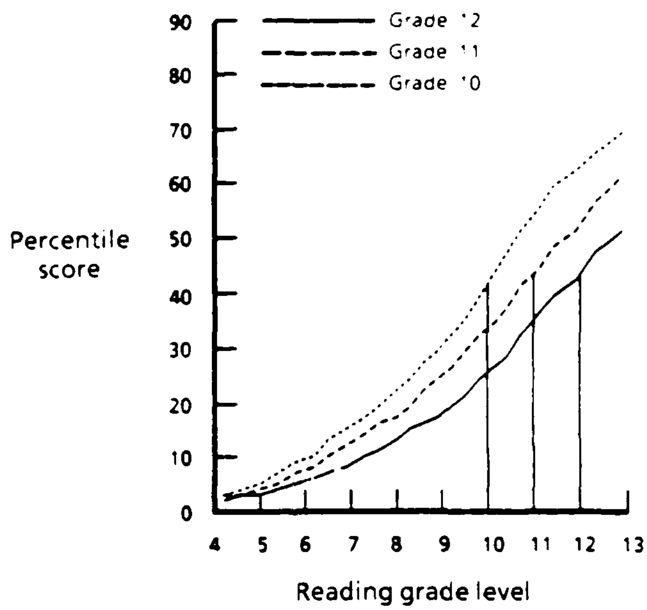

FIG. 24: TOTAL GROUP NORMS, VERBAL COMPOSITE: STANDARD SCORE CONVERTED TO C. A.T. GRADE LEVEL

1. For any given composite, grade 10 norms are based on the MEPCOM grade 10 sample and the transformation curve. The transformation is calculated from PAY grades 11 and 12 and MEPCOM grades 11 and 12.

REFERENCES

[1] U.S. Department of Defense. *Profile of American Youth: 1980 Nationwide Administration of the Armed Services Vocational Aptitude Battery.* Washington, D.C.: Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics), 1982

[2] Air Force Human Resources Laboratory, Technical Report 81-55, *Armed Services Vocational Aptitude Battery: Item and Factor Analyses of Forms 8, 9, and 10*, by Malcolm J. Ree, C. J. Mullins, John J. Mathews, and R. H. Massey, 1982

[3] U.S. Military Entrance Processing Command. *Technical Supplement to the Counselor's Manual for the Armed Services Vocational Aptitude Battery Form 14.* North Chicago: U.S. Military Entrance Processing Command, 1985

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[5] CNA, Memorandum 83-3135, *A Factor Analysis of ASVAB Form 8A in the 1980 DOD Reference Population*, by Peter H. Stoloff, Aug 1983

[6] U.S. Bureau of the Census, *1980 Census of Population: Detailed Population Characteristics. U.S. Summary Section A, United States*, Mar 1984

[7] CNA, Research Memorandum 86-86, *Inconsistent Scores on Speeded ASVAB Subtests*, by Gary E. Horne, Apr 1986

APPENDIX A

DETAILED DESCRIPTION OF DATA USED

APPENDIX A

DETAILED DESCRIPTION OF DATA USED

INTRODUCTION

Two sets of data were used in developing national Armed Services Vocational Aptitude Battery (ASVAB) norms for 10th grade students for seven composites of ASVAB subtests. These sets were (1) the 1980 national sample tested as part of the Profile of American Youth (PAY) study [A-1], and (2) results from students at selected high schools who were tested by the Military Entrance Processing Command (MEPCOM) from September 1984 to January 1985.

PAY DATA

The ASVAB was administered during the summer of 1980 to a nationally representative sample of 11,914 men and women, born during 1957 through 1964. All but 203 people in this sample were interviewed in April 1980 to get information such as the grade in school in which they were currently enrolled. Since this information was necessary to better define the sample, these 203 records were removed. Also edited out were 36 records of people who were administered the test in a nonstandard way.

PAY 11th and 12th Grade Sample – Selection 1

From the remaining sample, students were identified as 11th graders and 12th graders by using the interview question: "What grade or year of regular school are you attending or enrolled in?" [A-2]. If the response was "10," the student was flagged as an 11th grader; if the response was "11," the student was flagged as a 12th grader.

Justification for this selection is as follows. by the summer of 1980, most students flagged as 11th graders would have passed the 10th grade and would have been ready to start the 11th grade when tested in the PAY study. The word "most" is used because researchers had no way of identifying students who were not promoted to the 11th grade either because of failing and/or dropping out after the April interview. Justification for the selection of students flagged as 12th graders follows a parallel line of reasoning. This manner of identifying 11th and 12th graders will be referred to as "PAY selection 1."

PAY 11th and 12th Grade Sample – Selection 2

An additional 27 students were included as 11th graders and 37 students as 12th graders by using the following two additional interview questions: (1) "What is the highest grade of regular school you have ever attended?" and (2) "When were you last enrolled in regular school (month and year)?" Students who responded with "10" to question 1 and a date during the period of December 1979 through April 1980 to question 2 were included as 11th graders. Students who responded with "11" to question 1 and a date during the period of December 1979 through April 1980 to question 2 were included as 12th graders. In other words, students who dropped out of 10th grade after November are included in this selection as 11th graders and similar 11th grade dropouts are included as 12th graders.

Current 11th and 12th grade norms were developed by the Air Force Human Resources Laboratory for the seven composites using this selection. Therefore, this selection was used in this study as well. This manner of identifying 11th and 12th grade students will be referred to as "PAY selection 2." PAY selection 1 and PAY selection 2 are identical except for the inclusion of the 27 extra 11th graders and 37 extra 12th graders in PAY selection 2.

Weighting

The PAY data were weighted to reflect the 1980 population by age, gender, and race/ethnic groups. Norms were developed, based on weighted samples. Speeded test scores were adjusted according to the results of Wegner and Ree [A-3]. Table A-1 shows the unweighted and weighted sample sizes for PAY selection 1. Table A-2 shows the unweighted and weighted sample sizes for PAY selection 2.

MEPCOM DATA

The data from MEPCOM included records from 15,247 students tested in 52 schools. To eliminate substandard data, two basic types of editing were done: (1) editing of entire schools, and (2) editing of individuals from the acceptable schools. In addition, ninth grade records were not used in this study.

TABLE A-1

PAY SELECTION 1

Sample	Grade 11-unweighted		Grade 11-weighted	
	Frequency	Percent	Frequency	Percent
Male	662	51.8	2,090,598	51.0
Female	615	48.2	2,007,039	49.0
Black	348	27.3	583,228	14.2
Hispanic	218	17.1	259,625	6.3
White	711	55.7	3,254,785	79.4
Total	1,277		4,097,638	

Sample	Grade 12-unweighted		Grade 12-weighted	
	Frequency	Percent	Frequency	Percent
Male	622	51.2	1,773,448	51.3
Female	594	48.8	1,682,322	48.7
Black	345	28.4	498,745	14.4
Hispanic	226	18.6	223,594	6.5
White	645	53.0	2,733,431	79.1
Total	1,216		3,455,770	

TABLE A-2

PAY SELECTION 2

Sample	Grade 11-unweighted		Grade 11-weighted	
	Frequency	Percent	Frequency	Percent
Male	680	52.1	2,133,112	51.2
Female	624	47.9	2,035,396	48.8
Black	354	27.1	593,463	14.2
Hispanic	225	17.3	266,960	6.4
White	725	55.6	3,308,085	79.4
Total	1,304		4,168,508	

Sample	Grade 12-unweighted		Grade 12-weighted	
	Frequency	Percent	Frequency	Percent
Male	642	51.2	1,814,133	51.2
Female	611	48.8	1,726,571	48.8
Black	355	28.3	512,166	14.5
Hispanic	234	18.7	232,928	6.6
White	664	53.0	2,795,611	79.0
Total	1,253		3,540,704	

Editing of Schools

The MEPCOM test administrators were instructed to test all students present on the day of testing in each school so that, within each school, there would be no self-selection. This absence of self-selection is essential for avoiding biased samples. The most recent enrollment figures available at the United States Department of Education's National Center for Education Statistics [A-4 through A-8] were used as the primary sources for determining whether a sufficient number of students were tested. Two schools were edited out because their percentages of students tested fell below 70.

One additional school was rejected because an abnormally low percentage of 12th graders was tested, even though the overall percentage was acceptable. This smaller proportion of 12th graders could represent a selection of the least able (or most able) students in that grade, thus might not accurately reflect the proper progression of score distributions from 10th grade through 12th grade in that school.

Two schools were deleted because they lacked results from at least one entire grade. With a grade missing, the 10th through 12th grade progression could not be determined. A total of 47 schools in 18 states in all 4 regions of the United States (Northeast, Southeast, Midwest, and West) remained after editing. Figure A-1 shows the approximate locations of these 47 schools.

The date of testing was examined for these 47 schools. Test dates ranged from 28 September 1984 to 18 January 1985. All students were tested on the same date in 44 of the 47 schools. The other 3 schools tested on two dates separated by 1 day, 10 days, and 38 days. For the school with the gap of 38 days, the distributions of grade, gender, and race/ethnic group were checked. These distributions were found to be similar for the two testing sessions.

Editing of Individuals

In addition to the test results, MEPCOM gathered other information, including the race/ethnic background of each student. Thirty-four students were labeled "unknown" on race/ethnicity. They were removed because this information was necessary in matching the census percentages when weighting the MEPCOM schools. An additional 21 individuals were deleted because their grades were unknown.

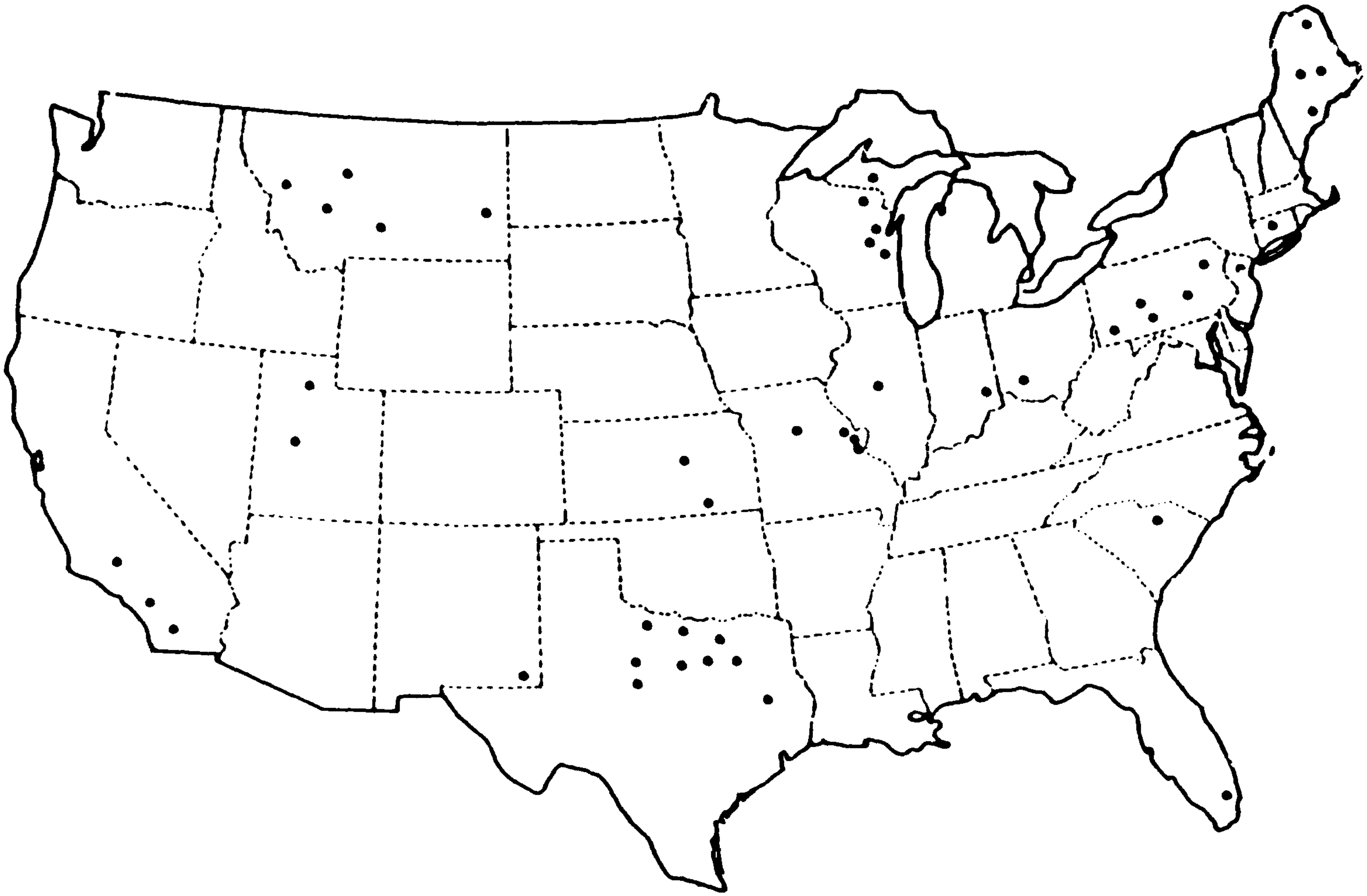

FIG. A-1: LOCATIONS OF ACCEPTABLE SCHOOLS IN MEPCOM SAMPLE

The study assumed that students who did not take the test seriously would cause the results to become distorted. Researchers expected some zero scores to occur by chance. However, if an individual omitted every item on one subtest, serious doubts were raised as to the student's effort on all the subtests. Thus, the entire record was removed if a student omitted all items on one or more subtest. When these records were deleted, the proportion of zero scores was comparable to that in the PAY data.

Finally, 17 records were deleted because the individuals were entered twice on the MEPCOM data tape.

Edited MEPCOM Sample

After editing, 14,061 of the original 15,252 cases remained. The cases that were edited out fell into five basic categories: (1) unacceptable school, (2) unknown race/ethnic group, (3) unknown grade, (4) all omits on any subtest, and (5) duplicated record. Twenty-one of the cases fell into two of these five categories, and the other 1,170 cases fell into only one of the categories. Table A-3 provides further information concerning the number of cases edited out.

TABLE A-3

NUMBER OF CASES EDITED OUT

Reason for editing	Number edited out
Unaccceptable school	876
Unknown race/ethnic group	34
Unknown grade	21
All omits on any subtest	264
Duplicated record	17
	1,212
Cases falling into 2 categories	− 21
Total	1,191

At the end of this process ninth graders were dropped, leaving 9,823 students in the data set used in the study. Final weighting of this sample will reflect many considerations, including the gender and race/ethnicity percentages in the 1980 census. Table A-4 shows frequencies for the edited, unweighted MEPCOM sample.

TABLE A-4

EDITED MEPCOM SAMPLE

Sample	Frequency	Percentage
Grade 10	3,878	39 5
Grade 11	3,263	33 2
Grade 12	2,682	27 3
Male	4,850	49 4
Female	4,973	50 6
Black	1,737	17 7
Hispanic	915	9 3
White	7,171	73 0
Total	9,823	100 0

REFERENCES

[A-1] U.S. Department of Defense. *Profile of American Youth: 1980 Nationwide Administration of the Armed Services Vocational Aptitude Battery.* Washington, D.C.: Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics), 1982

[A-2] National Opinion Research Center. *The Profile of American Youth User's Guide and Codebook.* Chicago: National Opinion Research Center, 1982

[A-3] Air Force Human Resources Laboratory, *Armed Services Vocational Aptitude Battery: Correcting the Speeded Subtests for the 1980 Youth Population*, by Toni Giuliano Wegner and Malcolm J. Ree, Jul 1985

[A-4] National Center for Education Statistics, *Enrollments of Public Schools in U.S. Printout for School Year 1980-81*, 22 Mar 1985

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APPENDIX B

DETAILS OF METHODOLOGY

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TRANSFORMATION METHOD

Steps in the Calculations

All calculations are performed independently for each composite and sex. The steps in the calculations are the following:

1. Compute frequency distributions in weighted PAY and MEPCOM samples. If a score has zero frequency, assign a nonzero frequency by linear interpolation of the cumulative frequency. (This is necessary for avoiding divisions by zero in step 5.)

2. For each composite score, calculate the percentile score from the PAY sample and cumulative percentage in the MEPCOM sample. This yields 61 points, i.e., pairs of values.

3. Use linear interpolation between successive points to calculate percentile scores corresponding to integer values of MEPCOM cumulative percentages.

4. For each integer value of MEPCOM percentage, compute the weighted mean of the two values obtained from the two grades. This yields the average transformation curve. The weights for grades 11 and 12, calculated to reflect their sample sizes, were .53 and .47 for males, and .52 and .48 for females.

5. At percentage values from 2 to 99, subtract the previous percentile score. The resulting differences are equivalent to frequencies in a distribution.

6. Smooth these frequencies, using a five-point moving average. The coefficients are $-3/35$, $12/35$, $17/35$, $12/35$, and $-3/35$ (page 516 of [B-1]). For percentages 2 and 98, where five points are not available, use a three-point rolling average with weights 1/4, 1/2, and 1/4.

7. Accumulate the recomputed frequencies to obtain the smoothed transformation.

8. In a lower grade (e.g., 10th), smooth the MEPCOM frequency distributions and calculate the cumulative percentage of each composite score. Using linear interpolation, find the corresponding percentile score from the smoothed transformation curve. The resulting value is the desired estimate of the percentile score in the national population. (This step is illustrated in figure 2 of the main text.)

Percentile score in the total population is the weighted average of values for the two sexes, the weights being the proportions of the sexes in the 1980 census.

Similarities to Equating

PAY percentile scores and MEPCOM cumulative percentages correspond to scores on old and new forms, respectively. The transformation curve yields the conversion from the new form to the old one. Each grade is a different population. The assumption that the transformation is the same in all grades is equivalent to the assumption that equating is independent of the population from which data were collected.

CHI-SQUARE TEST

One needs to assume that composite scores have a multivariate normal distribution. Analyses for the two sexes were performed independently, and effective sample sizes were used for all samples. Effective sizes of PAY samples were taken from table 27 in [B-2]. Those for MEPCOM samples were calculated from variances of weights (page 39 of [B-3]). Design effect for MEPCOM samples did not exceed 1.05.

Let X be a composite score, and z_{M1} the corresponding standard score in the MEPCOM grade 11 population. They are related by

$$x = \sigma_{M1} z_{M1} + \mu_{M1} ,$$

where subscripts M and 1 represent MEPCOM and grade 11, respectively. A similar equation holds for the PAY (i.e., national) population. Therefore, the MEPCOM and PAY standard scores corresponding to the same composite score are related by

$$z_{N1} = (\sigma_{M1} z_{M1} + \mu_{M1} - \mu_{N1}) / \sigma_{N1} \ .$$

When all distributions are normal, this defines the relationship between the PAY percentile scores and the MEPCOM cumulative percentages, i.e., the transformation curve obtained from grade 11 populations. If the transformation curve is grade invariant, the relationship between z scores must be the same in grade 12. This requirement gives us two conditions corresponding to the linear and constant terms in the equation. The linear term yields

$$\sigma_{M1} \sigma_{N2} - \sigma_{M2} \sigma_{N1} = 0 \ . \tag{B-1}$$

The condition obtained from the constant term can be expressed in two ways:

$$\sigma_{N2}(\mu_{M1} - \mu_{N1}) - \sigma_{N1}(\mu_{M2} - \mu_{N2}) = 0$$

or

$$\sigma_{M2}(\mu_{M1} - \mu_{N1}) - \sigma_{M2}(\mu_{M2} - \mu_{N2}) = 0 \ .$$

These equations are equivalent if (B-1) holds. They were added to maintain symmetry between PAY and MEPCOM quantities. Thus, the second condition is

$$(\sigma_{M2} + \sigma_{N2})(\mu_{M1} - \mu_{N1}) - (\sigma_{M1} + \sigma_{N1})(\mu_{M2} - \mu_{N2}) = 0 \ . \tag{B-2}$$

When sample values replace parameters in equations (B-1) and (B-2), the left-hand sides do not vanish. Denote their values by d_{ce}, where $c = 1, 2, ..., 7$ indicates the composite and $e = 1$ or 2 indicates the equation from which the difference was obtained. A test must be performed to determine whether the 14 observed values are, as a group, significantly different from zero.

The sampling distribution of mean scores is normal. So is that of sample standard deviations, to a very good approximation, when each sample is large. Each d contains quantities from four samples. Statistics obtained from different samples are independent. Since normality has been assumed, means and standard deviations are independent. However, means of different composites are correlated and so are their standard deviations. With $\bar{X}$ and s the usual symbols for sample mean and standard deviation,

$$Var(\bar{X}_c) = \sigma_c^2 / N$$

and

$$Cov(\bar{X}_c, \bar{X}_{c'}) = \sigma_{cc'} / N \ ,$$

where N is the sample size and σ_c^2, $\sigma_{cc'}$ are population variance and covariance [B-4].

Corresponding results for standard deviations require first-order Taylor expansion, which is valid when the sample is large. If

$$s_c^2 = \sigma_c^2 + e_c$$

where e_c is the sampling error in the estimated variance,

$$s_c \cong \sigma_c (1 + e_c / 2\sigma_c) \ .$$

Then

$$Cov(s_c, s_{c'}) = Cov(s_c^2 / 2\sigma_c, s_{c'}^2 / 2\sigma_{c'})$$

$$= (1/4\,\sigma_c \sigma_{c'})\, 2\sigma_{cc'}^2 / N$$

$$= \sigma_{cc'}\, \rho_{cc'} / 2N\ ,$$

where $\rho_{cc'}$ is the correlation between composites c and c'. These formulas remain valid when $c = c'$ [B-4].

The variance-covariance matrix of the ds can be calculated from these basic formulas. (The resulting expressions are too complicated to be reported here.) Let $\underline{S}$ be the estimated 14 x 14 matrix obtained by replacing parameters with their sample estimates. Let $\underline{d}$ be the vector of observed differences. The test statistic is $\underline{d}'\underline{S}^{-1}\underline{d}$. Its asymptotic distribution under the null hypothesis is chi-square with 14 degrees of freedom.

The chi-square statistics were 17.5 for males and 19.2 for females. The corresponding tail probabilities, obtained from the SAS package [B-5], are .23 and .16. Thus, the observed differences between 11th and 12th grade transformation curves are not statistically significant.

REFERENCES

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[B-2] U.S. Military Entrance Processing Command. *Technical Supplement to the Counselor's Manual for the Armed Services Vocational Aptitude Battery Form 14*. North Chicago: U.S. Military Entrance Processing Command, 1985

[B-3] Frankel, Martin R., and McWilliams, Harold A. *The Profile of American Youth: Technical Sampling Report*. Chicago: National Opinion Research Center, 1981

[B-4] Kendall, M. *Multivariate Analysis*. 2nd ed. New York: Macmillan, 1980

[B-5] SAS Institute, Inc., *Statistical Analysis System, Version 5.03*. Cary, NC: SAS Institute, Inc., 1986

APPENDIX C

ADDITIONAL RESULTS

APPENDIX C

ADDITIONAL RESULTS

Figures C-1 through C-14 present unsmoothed transformation curves obtained from grades 11 and 12. They show consistent patterns. For boys, the 11th grade curves lie above the 12th grade curves. This means that MEPCOM boys fell further behind those in the PAY sample. The case with girls is just the opposite: The 12th grade curve is higher (although by a smaller amount). As noted earlier, grade differences between transformations are not statistically significant, hence can be attributed to sampling fluctations. The major part of random error came from the PAY sample, which was much smaller than the MEPCOM sample (especially in terms of effective sample sizes after weighting).

With either sex, the difference between 11th and 12th grade transformations looks the same for all composites. This reflects the fact that the composites are strongly correlated.

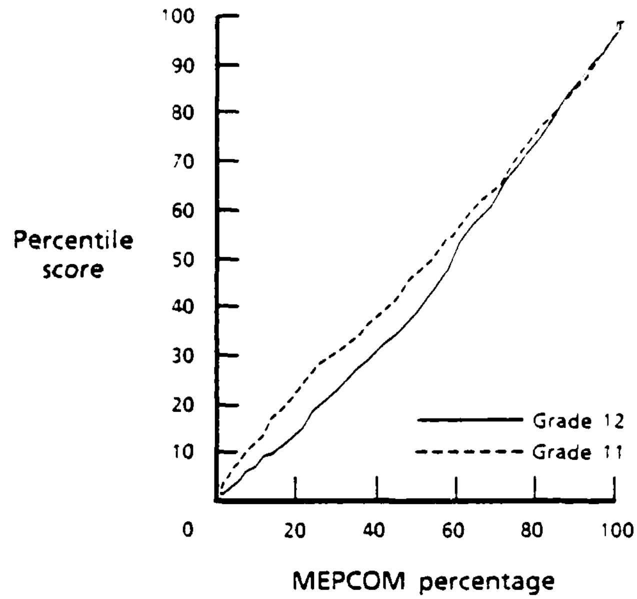

FIG. C-1: TRANSFORMATIONS FOR COMPOSITE AA (MALE SAMPLE)

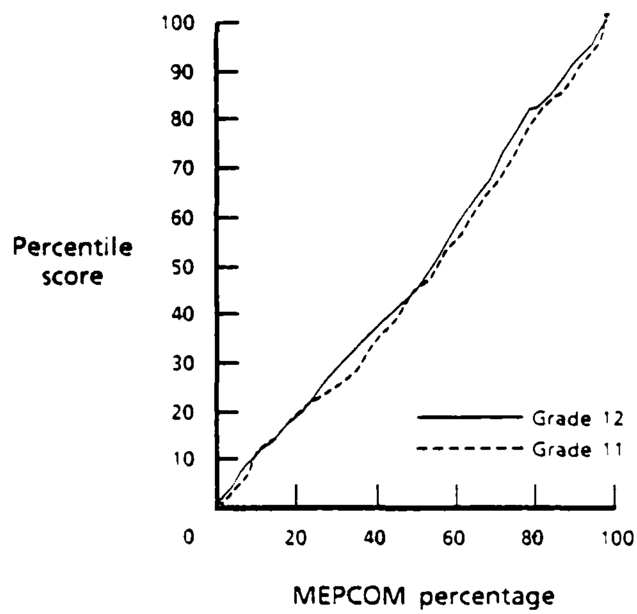

FIG. C-2: TRANSFORMATIONS FOR COMPOSITE AA (FEMALE SAMPLE)

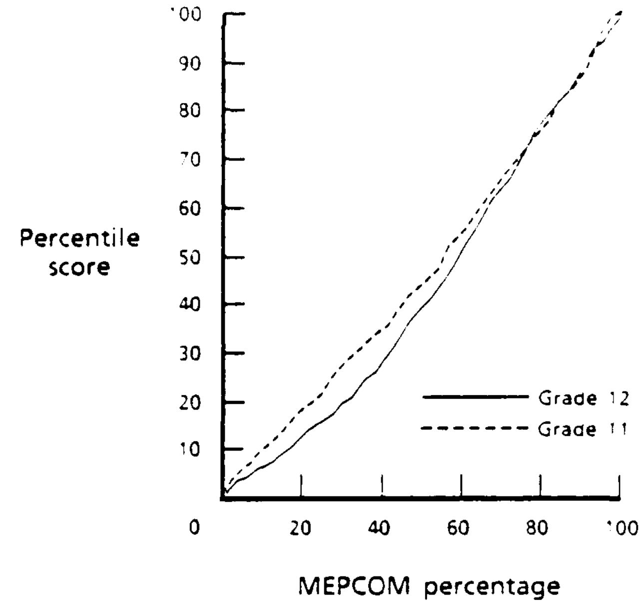

FIG. C-3: TRANSFORMATIONS FOR COMPOSITE VBL (MALE SAMPLE)

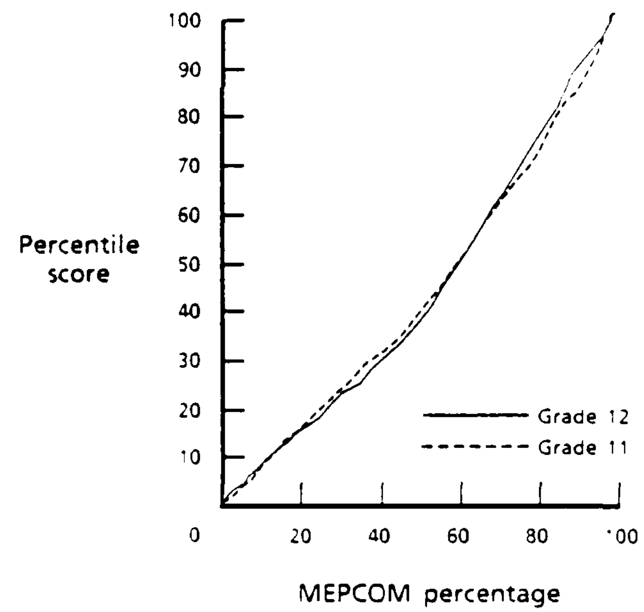

FIG. C-4: TRANSFORMATIONS FOR COMPOSITE VBL (FEMALE SAMPLE)

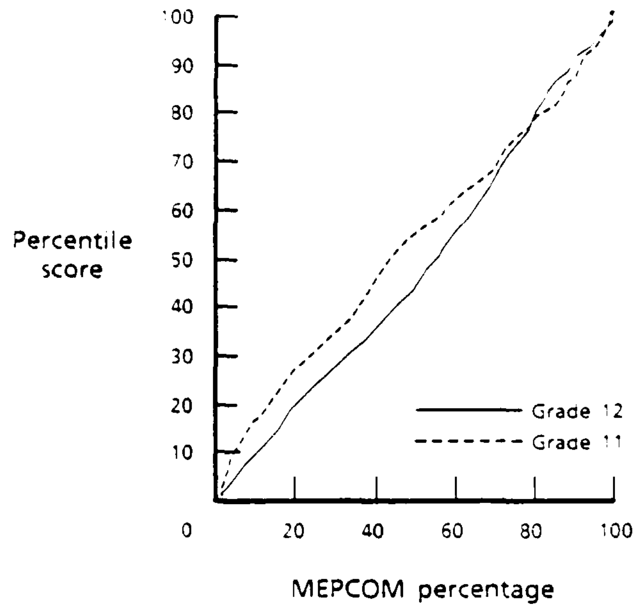

FIG. C-5: TRANSFORMATIONS FOR COMPOSITE MTH (MALE SAMPLE)

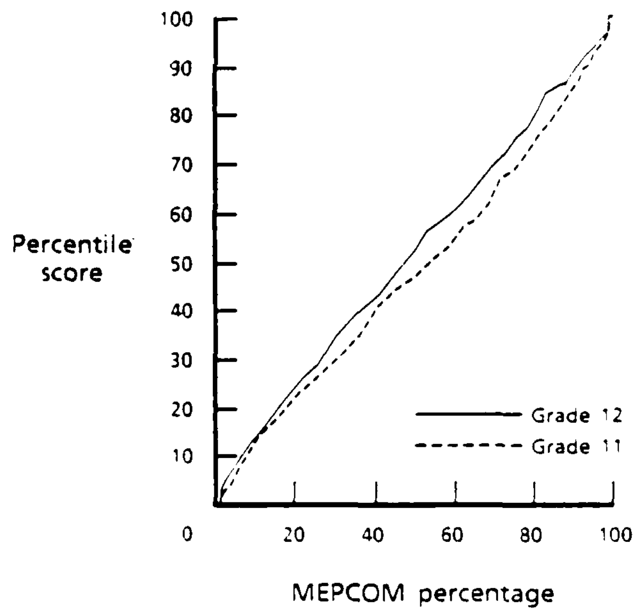

FIG. C-6: TRANSFORMATIONS FOR COMPOSITE MTH (FEMALE SAMPLE)

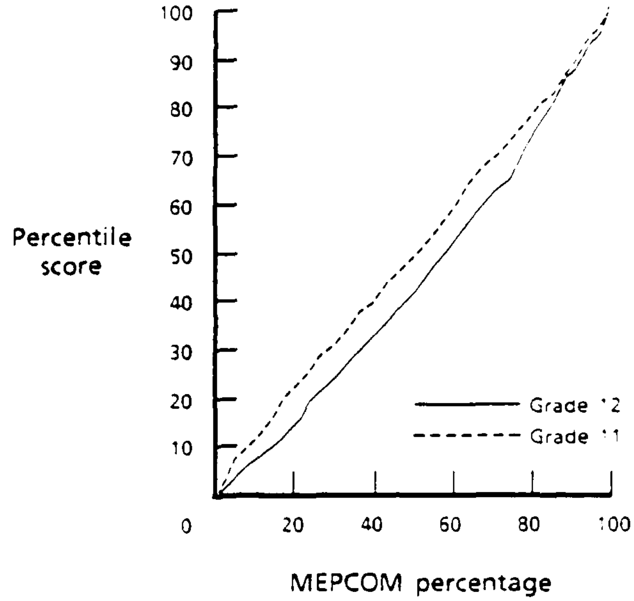

FIG. C-7: TRANSFORMATIONS FOR COMPOSITE M&C (MALE SAMPLE)

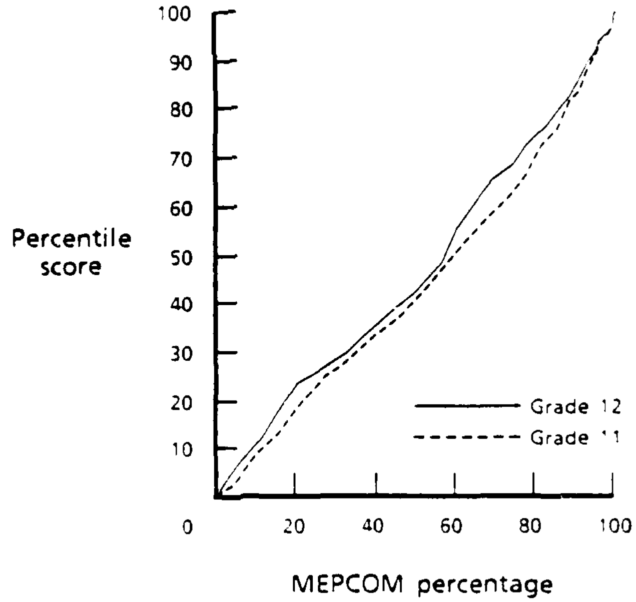

FIG. C-8: TRANSFORMATIONS FOR COMPOSITE M&C (FEMALE SAMPLE)

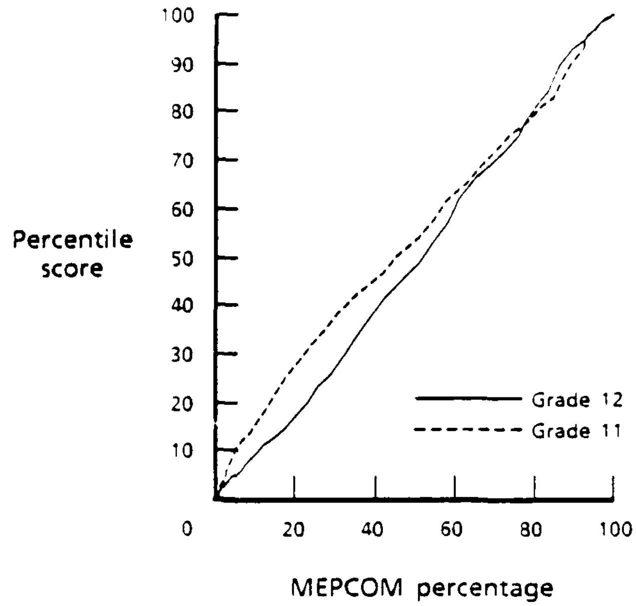

FIG. C-9: TRANSFORMATIONS FOR COMPOSITE BC (MALE SAMPLE)

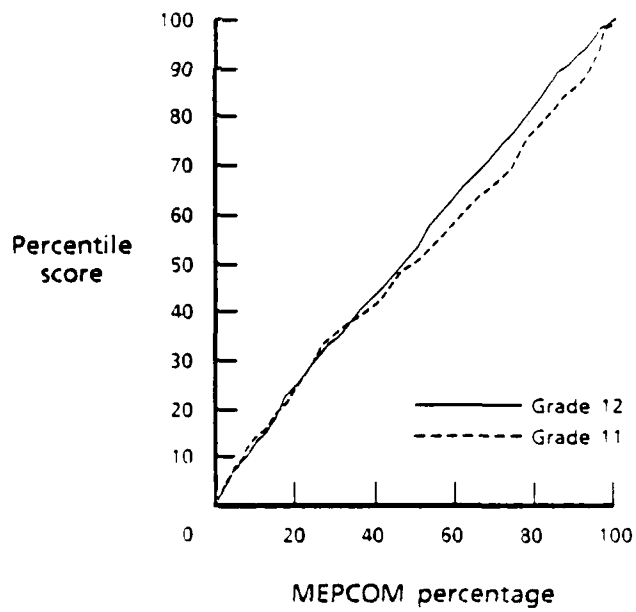

FIG. C-10: TRANSFORMATIONS FOR COMPOSITE BC (FEMALE SAMPLE)

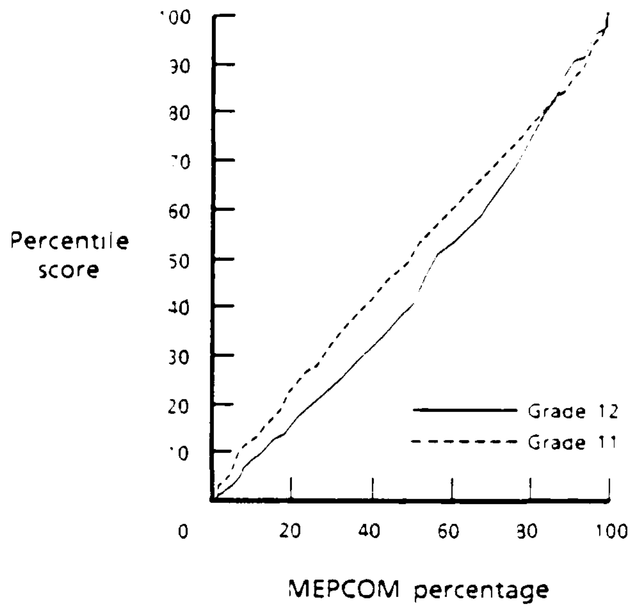

FIG. C-11: TRANSFORMATIONS FOR COMPOSITE EE (MALE SAMPLE)

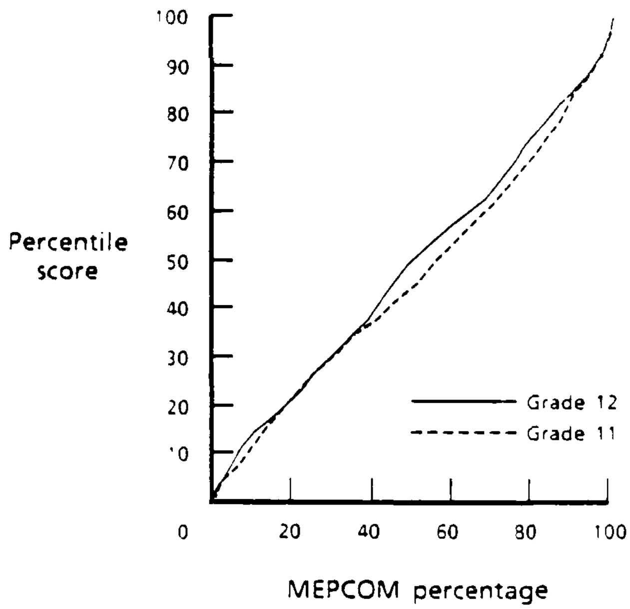

FIG. C-12: TRANSFORMATIONS FOR COMPOSITE EE (FEMALE SAMPLE)

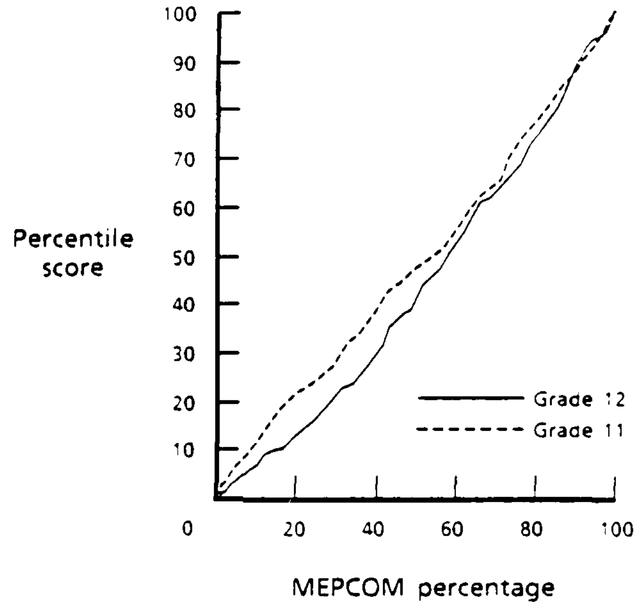

FIG. C-13: TRANSFORMATIONS FOR COMPOSITE HST (MALE SAMPLE)

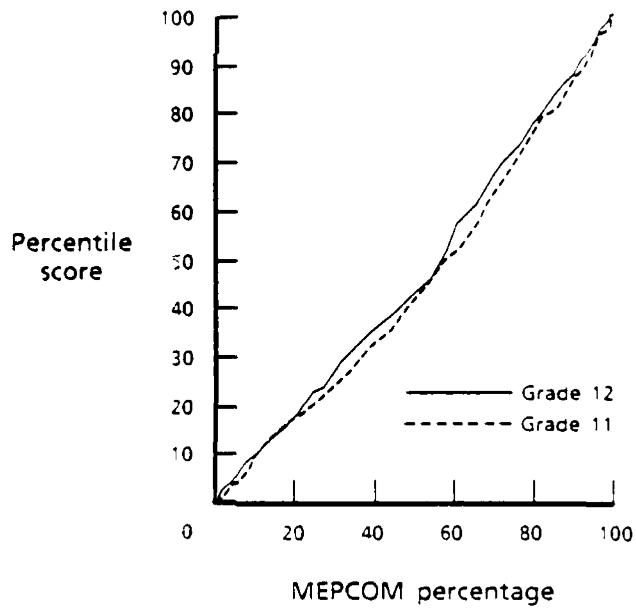

FIG. C-14: TRANSFORMATIONS FOR COMPOSITE HST (FEMALE SAMPLE)

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